3A Output, 96% Efficient Buck-Boost DC/DC Converter Sets the Standard for Power Density and Noise Performance

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High power density has become a primary requirement for DC/DC converters, as they must keep up with ever increasing functional density of electronics. Likewise, power dissipation is a major concern for today's functionally rich, tightly packed devices pushing the need for highly efficient solutions to minimize temperature rise. For applications where the input voltage source can be above or below the regulated output voltage, finding an efficient compact solution can be a challenge, especially at elevated power levels. Conventional design approaches, such as using a dual inductor SEPIC converter, produce relatively low efficiencies and relatively large solution sizes.

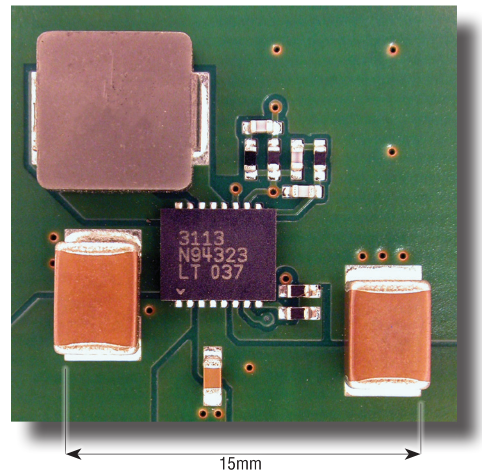


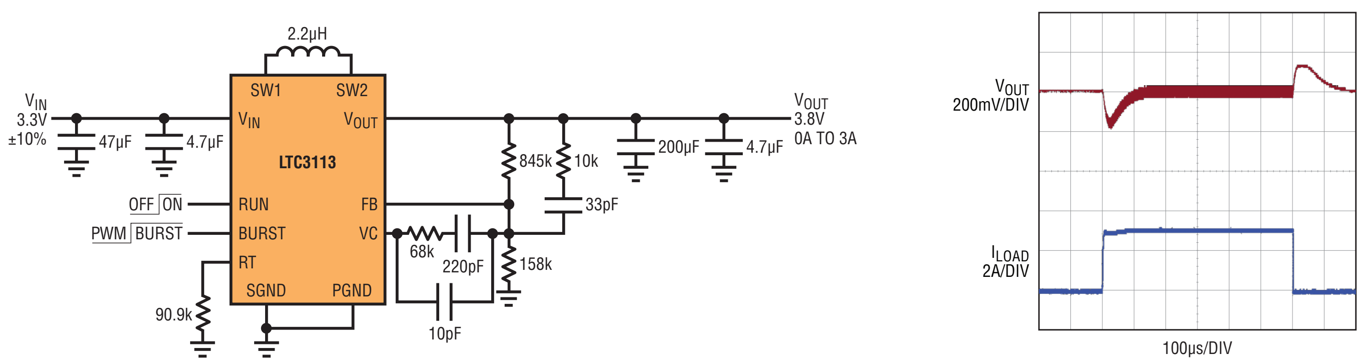
Figure 1. A typical application occupies 154mm²

The LTC3113 single inductor buck-boost converter offers a compact, highly efficient alternative. Internal low resistance switches allow the converter to support an impressive 3A of load current in a tiny 4mm × 5mm package. The LTC3113 offers an extended input and output operating voltage range from 1.8V to 5.5V, with peak efficiencies reaching 96%. The internal PWM controller is designed for low noise performance and offers a seamless transition between buck and boost modes. The combination of these features allows the LTC3113 to easily meet challenging high density power requirements.

Figure 1 shows an 11mm × 14mm × 2.5mm LTC3113-based solution that can supply up to 12W of output power from a Li-ion battery. This translates to a power density of 31mW/mm³ (511W/in³). A complete SEPIC design would require twice as much PCB area, resulting in half the power density and significantly lower efficiency, which complicates thermal design.

The LTC3113 offers a number of options to optimize performance for specific applications, including the ability to adjust the operating frequency from 300kHz to 2MHz, internal soft-start, user selectable Burst Mode® operation for improved efficiency at light load currents, and a host of fault protection features including short-circuit protection and thermal shutdown. The LTC3113 is available in both a 4mm × 5mm DFN and a 20-pin thermally enhanced TSSOP.

Figure 2. Pulsed load or portable RF power amplifier power supply and typical output response



The LTC3113 single inductor buck-boost converter offers a unique combination of features to meet challenging high density power requirements. Internal low resistance switches allow the converter to support an impressive 3A of load current in a tiny 4mm × 5mm package, with peak efficiencies reaching 96%. The internal PWM controller is designed for low noise performance and offers a seamless transition between buck and boost modes.

GSM APPLICATION

Many GSM applications require expensive supercapacitors on the DC/DC output supply rail to support the temporary heavy loads placed on the output by the power amplifier during transmission bursts. In many cases, the high output current capability of the LTC3113 is sufficient to support the transmit current without the need for supercapacitors. Figure 2 shows such a circuit and associated typical load transient for an RF power amplifier using a standard, inexpensive 100µF ceramic capacitor on the 3.8V output.

The oscilloscope photo shows the response of the 3.8V output when a 3A load pulse lasting 580µs is applied. For this extreme case the output voltage undershoots only 150mV (4.5%) and quickly recovers. The output voltage overshoot when the load is removed shows a similar response. For this external load pulse, the transient response has been optimized by tailoring the compensation to minimize the effects of the load step.

NOISE PERFORMANCE

Many applications, including RF transmission, are sensitive to noise generated by switching converters. The LTC3113 uses a low noise switching architecture to reduce unwanted subharmonic frequencies, which occur below the operating frequency and can interfere with other sensitive circuitry. These subharmonics usually occur when V_{IN} and V_{OUT} are approximately equal. Buck-boost converters operating in this region typically produce pulse width and frequency jitter—a result of all four switches changing state during a single switching cycle. The LTC3113 minimizes the magnitude of the jitter or subharmonic frequencies to satisfy the requirements of noise-sensitive RF applications.

Figure 3 shows worst-case spectral comparisons of the LTC3113 and a competitive buck-boost converter without the low noise architecture of the LTC3113. The worst-case condition was achieved by placing a fixed 1A load on the output and slowly increasing or decreasing the input voltage until the greatest harmonic content in the converter spectrum was observed. The LTC3113 exhibits an expected single large magnitude tone at its switching frequency of 2MHz. In contrast, the competing buck-boost exhibits several high magnitude subharmonic and harmonic tones across the entire frequency range, indicative of significant pulse width jitter and potential noise interference issues. Note also that the overall noise floor of the LTC3113 is 10dB to 20dB lower than the competition across the entire frequency range.

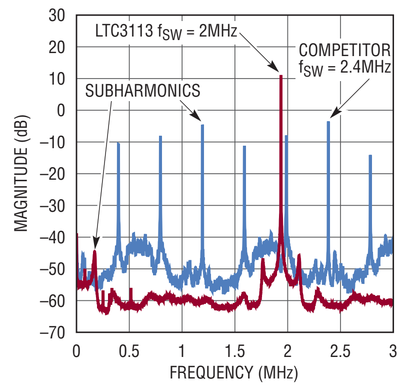
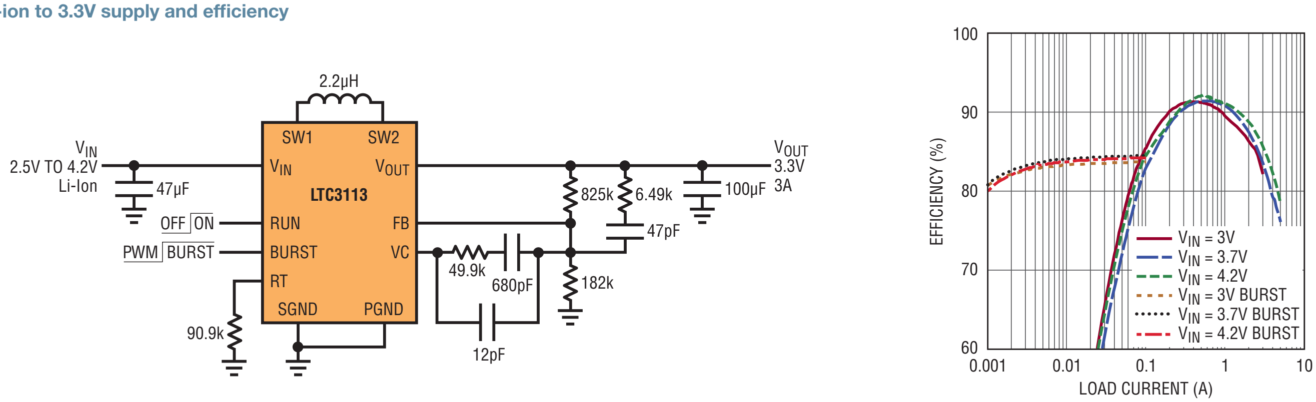


Figure 3. Spectral comparison of the LTC3113 and typical competitor's part

Figure 4. Li-ion to 3.3V supply and efficiency



The LTC3113 monolithic buck-boost converter breaks new ground in power density, low noise operation and high efficiency across a wide range of load currents.

SINGLE LI-ION TO 3.3V, 10W CONVERTER

Besides generating bias voltages for RF power amplifiers, creating a 3.3V rail from an input source such as a Li-ion battery is another common application for a buck-boost converter. The LTC3113 can provide up to 10W (3.3V/3A) of output power over the Li-ion battery's usable range. Figure 4 shows a typical application schematic used to generate 3.3V. Also shown are the associated efficiency curves for different battery voltages over a range of load currents for this application. The efficiency peaks at 92% and efficiencies greater than 80% are achieved from loads ranging from 60mA to 3A. Burst Mode operation employs a variable frequency-switching algorithm to maintain highly efficient conversion at lighter loads.

Setting the BURST pin to a voltage greater than 1.2V allows the LTC3113 to enter Burst Mode operation at light loads to maximize efficiency. For noise sensitive applications the converter can be forced into fixed frequency operation by keeping the voltage on the BURST pin below 0.3V.

BACKUP POWER SYSTEMS

Figure 5 shows a supercapacitor-powered backup power supply system, where the LTC3113 is used to provide a regulated 3.3V output at a constant 1.5A load. In this application, two series 30F supercapacitors have been charged to 4.5V during normal operation to provide the needed backup energy when the primary power is lost.

The scope photo shows that the LTC3113 can regulate the output for 22.5s when powered only by the two series 30F capacitors. Over this time, the capacitors discharge from an initial 4.5V to just below 1.8V—output regulation over this input range is only possible because of the LTC3113's low input voltage capability. In this example, the amount of energy supplied by the input is:

$$E_{IN} = \frac{1}{2} \bullet C \bullet \left[\left(V_{INITIAL}\right)^2 - \left(V_{FINAL}\right)^2 \right]$$

$$E_{IN} = \frac{1}{2} \bullet 15F \bullet \left(4.5V^2 - 1.8V^2\right) = 127.6J$$

The output is regulated to 3.3V with a constant load of 1.5A for 22.5s, which yields output energy of:

$$\begin{aligned} E_{OUT} &= I_{OUT} \bullet V_{OUT} \bullet t \\ &= 1.5A \bullet 3.3V \bullet 22.5s \\ &= 111.4J \end{aligned}$$

This shows that about 87% of the available input energy is converted to output power. The solution size for this application is about 11mm × 14mm, excluding the area of the supercapacitors.

CONCLUSION

The LTC3113 monolithic buck-boost converter breaks new ground in power density, low noise operation and high efficiency across a wide range of load currents. The LTC3113 is an ideal solution for battery-powered products, backup power supply systems and RF or other noise-sensitive applications. ■

Figure 5. Supercapacitor-powered supply and typical output response with 1.5A load